SOLAR DISTILLATION USING FRESNEL LENS AND PARABOLIC REFLECTOR WITH INTEGRATED DRIP MECHANISM

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ABSTRACT

This paper aims at developing an apparatus which will provide pure drinking water without the need of electric current and expensive filtration apparatus. Solar energy is the only energy used in this apparatus. The effectiveness of solar collection is increased by the integration of Fresnel lens and parabolic reflector. Drip mechanism is used for solar tracking which is both effective and economical. Unconventional desalination systems are costlier and require high maintenance cost. So this situation forced society to depend on conventional technologies. Thus we have built a system to answer the demands of the society. The main aim is to develop an apparatus to provide drinking water for the society with increased feasibility and also at reduced cost with zero carbon emissions.

Keywords: *Solar distillation, Fresnel lens, solar collector, parabolic reflector, drip mechanism.*

1. INTRODUCTION

Solar energy is the energy that is produced by the sun in the form of heat and light [1]. All animals directly or indirectly depend upon plants for their survival. Thus solar energy forms the basis of the ecosystem as the plants synthesizes the solar energy. Solar energy is widely collected and used by various technologies. Using solar energy to convert saline water into drinking water is called as solar desalination. There are both conventional and renewable technologies available for water desalination [2]. Conventional technologies use fossil fuels as their energy source. They emit gases which affect both the environment and ecosystem [3]. In order to tackle this problem many desalination technologies based on renewable energy are widely used in recent times.

Out of all the desalination technologies, solar desalination is the best sustainable alternative [4]. The use of solar desalination contributes significantly to reducing global warming. There are two types of solar desalination technologies. They are direct and indirect collection systems. In the former, solar energy is absorbed and used in the same piece of equipment whereas in the latter, two separate sub-systems are used, one for solar energy conversion and one for desalination [5]. There are various technologies in the direct and indirect solar desalination technologies. Each of the technologies has certain advantages and disadvantages [6]. Whichever technology we use the energy collected and expended must be minimized while the output is increased. A review made by Arun Subramani explains the various energy minimizing strategies to be followed for maximum efficiency during desalination [7]. An excellent review on the use of small scale solar desalination plant in the remote arid areas was presented by Bachir Bouchekima [8]. A review on the suitability of using solar desalination in India was presented by T.V.Arjunan. In this review he assess that solar desalination is especially suited to small-scale units at locations where solar energy is considerable [9]. It is because India is blessed with plenty of sunshine as it is a tropical country. Even though solar desalination technologies are maturing, there still is a huge potential for development [10].

As the above literature review shows; there is a huge potential for increasing the effectiveness of solar desalination technologies. As a result, direct active desalination using the integration of Fresnel lens, parabolic reflector and drip mechanism is put forward to increase the yield of the solar desalination.

2. OBJECTIVE

1. To eliminate the usage of expensive filtration units and eliminate the consumption of electrical energy.
2. To provide a system with less maintenance and a long life time.
3. To reduce the size, weight and price of the desalination apparatus.
4. To provide a feasible solution to the drinking water crisis in the world.
5. To achieve zero carbon emission during testing and procedure

3. EXPERIMENTAL SETUP

The water tank is made up of mild steel sheet, rolled to form a cylinder. The ends are welded which closes the tank. The tank is painted in black colour to increase absorptivity. An inlet and outlet for water are provided with pipes and are welded to the tank. The welded portions are sealed using m-seal to prevent leaks. A hole is drilled into the tank to provide the outlet of the steam. A copper pipe is wound in a shape of helix. The copper pipe is welded to the tank and is immersed in a container containing water. This container acts as a homemade condenser. The condensing unit is placed under a shadow to increase the rate of condensation. A satellite dish is taken and reflector tape is pasted onto its surface. This satellite dish along with the reflective tape acts as a parabolic reflector.

The water tank is placed at the focus of the parabolic reflector so that the sunlight falling on the reflector is entirely reflected to the tank. Fresnel lens is mounted over the tank in such a way that the converged sunlight falls over the water tank. A stand is prepared to support the units in their appropriate positions.

The design is divided into three major parts: (i) Solar collection unit, (ii) Desalination unit and (iii) Condensing unit. Solar collection unit consists of Fresnel lens and parabolic reflector. The water tank comes under the desalination unit. The helical copper tube and the cooling water container comes under the condensing unit.

4. PERFORMANCE EVALUATION

The desalination unit along with Fresnel lens and parabolic reflector are tested for maximum efficiency for evaluation of performance. Infrared thermometer is used for temperature measurement of the water tank. Test measurements were taken from 8.00 AM to 5.00 PM, The water volume is maintained constant at 1 litre. The drip mechanism is attached to the parabolic reflector. The setup is placed in such a way that the parabolic reflector gets aligned exactly to the sun in the correct position. The time taken to evaporate and to condense the steam and the quantity of water evaporated is noted.

5. PERFORMANCE CALCULATION

The efficiency of the system depends upon the solar irradiance, transmissivity of Fresnel lens and reflectivity of parabolic reflector. Model calculations are obtained by making appropriate assumptions. The month of testing is February and the location is Tiruchirappalli (Latitude: 10.75 Longitude: 78.75)

5.1 SOLAR IRRADIANCE AND HEAT FLUX

Solar irradiance is the power per unit area received from the Sun in the form of heat and light recorded by the instrument.

Heat flux is defined as the amount of heat transferred per unit area per unit time from or to a surface.

$$\text{Heat flux} = (\tau\alpha A_1 I \div A_2) + (\alpha\rho I A_3 \div A_2)$$

Where,

S = heat flux, W/m^2

τ = transmissivity of Fresnel lens

α = absorptivity of water tank

ρ = reflectivity of parabolic reflector

I = intensity of solar radiation, W/m^2

A_1 = surface area of Fresnel lens, m^2

A_2 = surface area of water tank, m^2

A_3 = surface area of parabolic reflector, m^2.

5.2 RATE OF EVAPORATION

An evaporation rate is the rate at which a material will vaporize (evaporate, change from liquid to vapor) compared to the rate of vaporization of a specific known material.

$$\text{Rate of evaporation} = S \div h_{we}$$

Where,

g_s = amount of evaporated water, kg/s

h_{we} = rate of evaporation of water, J/kg

6. RESULTS AND DISCUSSION

The solar desalination apparatus is tested for its performance theoretically. There were two cases to be considered. The calculations provide an average rate of evaporation for both the cases.

6.1 Morning and Evening

During morning and evening both the Fresnel lens and parabolic reflectors are in use. The shadow cast by the water tank is negligible compared to the surface area of parabolic reflector. The solar heat flux was found to be 2714.96 W/m^2. The corresponding rate of evaporation was found to be 0.0012 kg/s.

6.2 Noon

During noon parabolic mirror will not function as the shadow cast by the Fresnel lens will cover the entire surface. So during noon only the Fresnel lens will function. But still the solar heat flux and rate of evaporation remains nearly same as that of the morning and evening case, since the solar intensity is maximum during noon. The solar heat flux was found to be 2665.96 W/m^2. The corresponding rate of evaporation was found to be 0.00118 kg/s.

7. CONCLUSION

Solar energy has the best potential to become a feasible solution to the growing energy and water crisis in the planet. There is a huge untapped area for development of technologies based on solar energy. The usage of Fresnel lens and parabolic reflector greatly increases the rate of evaporation of water. The results in our study shows a promising usage in rural and coastal areas both efficiently and economically. The system is cost efficient and can be implemented feasibly in small scale.

8. REFERENCES

[1] Sarada Kuravi, Jamie Trahan, D Yogi Goswami, Muhammad M Rahman, Elias K Stefanakos, “Thermal energy storage technologies and systems for concentrating solar power plants”, *Progress in Energy and Combustion Science*, Volume 39, Issue 4, Pages 285-319.

[2] Mahmoud Shatat, Mark Worall, Saffa Riffat, “Opportunities for solar water desalination worldwide:

Review", *Sustainable Cities and Society*, Volume 9, December 2013, Pages 67-80.
[3] F W Taylor, "The greenhouse effect and climate change", *Reports on Progress in Physics*, Volume 54, Number 6.
[4] Mahmoud Shatat, Saffa B. Riffat, "Water desalination technologies utilizing conventional and renewable energy sources", *International Journal of Low-Carbon Technologies*, Volume 9, Issue 1, 1 March 2014, Pages 1–19.
[5] Soteris Kalogirou, "Survey of solar desalination systems and system selection", *Energy*, Volume 22, Issue 1, January 1997, Pages 69-81.
[6] Muhammad Tauha, Ali Hassan, E.S.Fath Peter, R.Armstrong, "A comprehensive techno-economical review of indirect solar desalination", *Renewable and Sustainable Energy Reviews*, Volume 15, Issue 8, October 2011, Pages 4187-4199.
[7] Arun Subramani, Mohammad Badruzzaman. Joan Oppenheimer, Joseph G.Jacangelo, "Energy minimization strategies and renewable energy utilization for desalination: A review", *Water Research*, Volume 45, Issue 5, February 2011, Pages 1907-1920.
[8] Bachir Bouchekima, "Solar desalination plant for small size use in remote arid areas of South Algeria for the production of drinking water", *Desalination*, Volume 156, Issues 1–3, 1 August 2003, Pages 353-354.
[9] T.V.Arjunan, "Status of solar desalination in India", *Renewable and Sustainable Energy Reviews*, Volume 13, Issue 9, December 2009, Pages 2408-2418.
[10] Lourdes Garci, "Renewable energy applications in desalination: state of the art", *Solar Energy*, Volume 75, Issue 5, November 2003, Pages 381-393.